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MEMORANDUM ON LABORATORY RECORDS

JANUARY TO APRIL, 1936

CRITICAL LOW TEMPERATURES FOR THE WESTERN PINE AND MOUNTAIN PINE BEETLES

by
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Berkeley, California
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Submitted by:

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The purpose of this memorandum is not to make a detailed report, but to prepare a record of the data before the advent of the field season. It covers experiments run since the last memorandum was submitted.

WESTERN PINE BEETLE STUDIES

As mentioned in the preceeding memorandum, the greater portion of the time has been devoted to the mountain pine beetle studies, so there is little to report on Dendroctonus brevicomis.

1. Test of Active Larvae:

Some active brood from the Central Sierra was tested in the early spring (No. 45). It was found that the critical range was about the same as that usually found in winter brood; mortality set in between 2° and 5° Fahr., and was complete at -5° Fahr. This indicates that although the larvae had resumed activity, they had lost little of their cold resistance. Probably individuals which pass the winter as full grown larvae do not revert to the less resistant summer condition, for we found that in this resistant material pupation was taking place, and as already reported, the pupae are even more resistant than the larvae.

2. Experiment on Conditioning:

An attempt was made to condition larvae of the same brood (No. 48). One lot of bark was held at 36° Fahr. for 18 days, another lot was held 28 days at 36° Fahr., and a third lot, having been exposed to 36° Fahr. for 18 days, was given an additional period of 10 days at 20° Fahr. In each of these the larvae showed no appreciable difference in resistance from the original material. This is quite a contrast to the results when Dendroctonus monticolae is used.

3. Effect of Prolonged Exposure at 7½° Fahr.:

A third test (No. 49) was made for the purpose of determining the effect of prolonged exposure near upper critical points (7½° F.). This test was not finished at the time of writing, but the results at hand indicate that there is a very slight increase in mortality up to 48 hours, and higher mortality after 3 and 4 days exposure. There also appears to be a retarding in the rate of pupation after prolonged exposure.

With the acquisition of more efficient refrigeration equipment, it will be possible to make a more complete study of the effect of time of exposure at the different critical points.

MOUNTAIN PINE BEETLE STUDIES

The methods employed are the same as those given in the preceding memorandum and the work is almost entirely a continuation of those experiments.

1. Critical Temperatures Affecting Larvae in Relation to Host Trees:

In continuing tests to determine the effect different hosts have upon cold resistance, broods of known parentage were used, similar to those previously employed. The results of these two tests further substantiate the earlier observations (See Figure 1, page 5).

a. Differences due to seasonal changes continued with the occurrence of colder weather in the latter part of December and early part of January. The critical range for larvae in each of the three hosts, sugar pine, ponderosa pine, and lodgepole pine was quite markedly reduced; the ultimate point falling between -10° F. and -12½° F. Following this period of cold weather, there came a contrasting period of quite warm weather, during which day temperatures approaching summer heights prevailed. Although there is apparently little development during this time, it is quite evident that there was a pronounced effect on the larvae. The test made on March 14 showed that the cold-hardiness had been materially reduced; the ultimate critical points falling between +2½° F. and -5° F., instead of -10° F. to -12° F., as in the preceeding test. Unfortunately, there is no more material available to follow this overwintering brood through the remainder of its development.

Although the number of tests made were not as numerous as might be desired, and the weather conditions did not follow the normal yearly cycle, it is felt that the results given in this and the preceeding memorandum present a very good qualitative, if not quantitative picture of the change in cold-hardiness through the winter season. There is one point, however, which throws some shadow of question on the entire work. When the infested logs were stored at Chinquapin during the fall and winter, moisture soaked up under the bark and with the advent of cold weather much of the brood became encased in a layer of ice. Just what effect this had, we do not know, but at least it does leave a question.

b. The difference due to host conditions continued to be evident. However, in the midwinter test (January 13), the ultimate critical points are nearly the same for the larvae from all three hosts, -10° F. to -12½° F., although the mortality at the higher temperatures is greatest for the larvae from sugar pine and least for the lodgepole larvae. When the peak resistance of mid-winter is past, the same difference that was evident in the fall again appears; the larvae from sugar pine being much less resistant than those from ponderosa or lodgepole pine.

There still seems to be no pronounced difference between ponderosa pine and lodgepole pine larvae. Additional work under more carefully controlled conditions with new information, which it is hoped can be secured from nutritional studies, may bring much more complete information on this point of host effect.

2. The Effect of Previous Conditioning of Larvae on the Critical Range:

In the tests made during the fall it was brought out that the resistance of larvae which were not yet in the winter conditions could be quite definitely increased by prolonged exposure to low temperatures along the critical range. This demonstrated that the hardening of larvae during the fall is evidently, as is commonly believed, due in part to the lowered temperatures at that season, rather than a definite periodicity, as is found in some insects. The next question which arose concerned changes which might occur with the removal of winter temperature conditions. To answer this question, material in the most resistant condition was held at 75° F. for 14 days and the critical range then determined (See Figure 2, page 6). It was found that the resistance had been reduced to about midway between the summer and winter conditions. A portion of this active material in lodgepole pine was placed at 36° F. for 23 days, to see whether these active larvae could again develop a resistant condition. When tested, the ultimate critical point was found to be about the same as that for the active larvae, but the intermediate points seem to show somewhat more resistance. There was no close approach, however, to the original resistant conditions. The development of cold resistance, it seems, is more than just a matter of exposure to conditioning temperatures.

3. Critical Temperatures Affecting Larvae in Relation to Locality:

Because of lack of material, practically nothing was done on this phase since the first of the year. Some larvae in ponderosa pine were secured from the Modoc National Forest on March 16. This brood had been exposed to a period of quite warm weather and consequently had lost its winter resistance; the critical range beginning at 14° F. and the ultimate point being reached at 0° F.

COMMENTS

The past 18 months of these cold-hardiness studies have brought to light some very interesting results which have opened the way to new avenues of approach to the problem. With the acquisition of new equipment it will be possible to more carefully recheck past findings, and in addition, to follow more completely the changes which occur. Since this new equipment will be semi-portalbe, it may be possible to make some of the tests in the field and thus eliminate the question of changes which may, at present, occur during transportation from the field to the laboratory at Berkeley.

In the plan for future studies it would be desirable to cover as many as possible of the following points:

1. Follow a complete yearly cycle on larvae from both the Central Sierra and the colder northern areas (Modoc and Lassen National Forests).

2. A more complete study of host effect, particularly toward determining whether physiological strains exist. To this end, it would be

very desirable to import parent adults from other regions, such as the Klamath and Montana, rear a brood of larvae from these parent adults at the Central Sierra field station, and determine whether the individuals are more resistant by inheritance.

3. More complete studies on the temperatures and duration of exposures which induce a greater cold resistance.

4. Studies of water and fat content of larvae with respect to cold-hardiness. It has been shown in some insects that the increased cold resistance is definitely associated with a loss of water content and a high fat reserve. It would be interesting to determine whether water and fat content are a factor in the case of barkbeetles and would also be interesting to compare the water and fat content of larvae from different climatic regions.

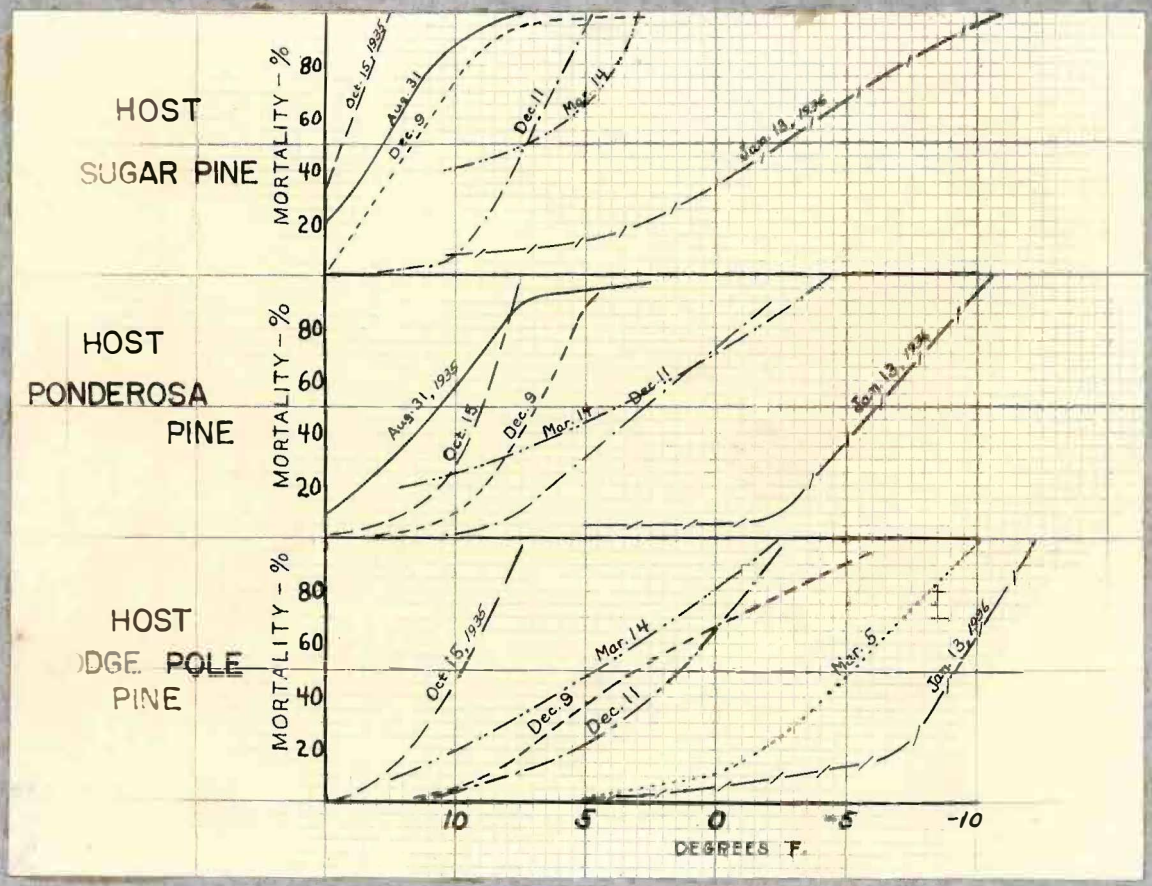

Figure 1

Figure 1 includes mortality curves given in the first memorandum in order to give the entire range of seasonal changes. For each host the percent mortality is plotted against the temperature at which the exposures were made. Each curve is labeled with the date the tests were made.

The larvae from each host show a decided increase as the fall and winter progressed (August 31 to December 11, 1935), reaching a maximum on January 13, 1936. With the passing of the winter period (March 5 and 14, 1936), the resistance regressed to a range similar to that which had occurred in the fall. There are discrepancies in that the larvae from sugar pine tested August 31 were more resistant than those tested October 15, and the larvae from lodgepole pine tested December 9 had a lower ultimate point than those tested December 11. These differences are probably due to experimental error.

In comparing differences in resistance of larvae from different hosts, exposed under the same conditions, it appears that the larvae from sugar pine are much less resistant than those from ponderosa and lodgepole pine during the fall and early winter (October 15 to December 11, 1935). However, at the time of maximum resistance (January 13, 1936) larvae from all three hosts have about the same ultimate point, -12½° F., although in the intermediate range, the larvae from sugar pine were appreciably less resistant. Tests made in the spring (March 14, 1935) show that the difference in resistance has become greater as the environmental temperatures have become higher. The difference in resistance between the larvae from ponderosa pine and lodgepole pines is less evident, although the latter seem to be somewhat hardier.

THE EFFECT OF PREVIOUS CONDITIONING OF LARVAE

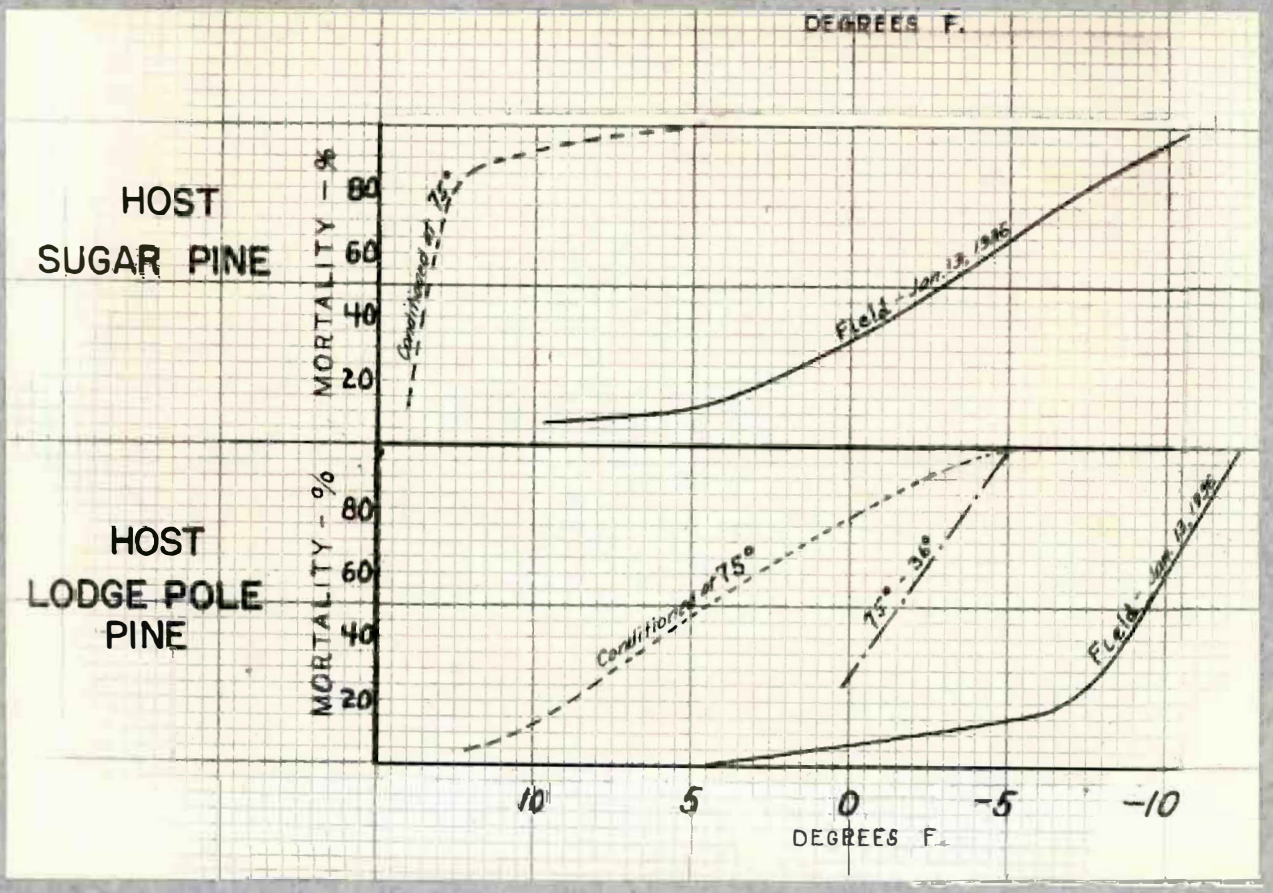

Figure 2

These curves show the effect of exposures to conditioning temperatures upon the critical range of larvae. The mortality is plotted against the temperature of the exposures. The labeling on the curves indicates the conditioning employed.

The material as it came from the field (Field - January 13, 1936) shows the critical range at the time of greatest resistance to be from about +10° to -11° F. for larvae from sugar pine and from about +5° to -12½° F. for the lodgepole pine larvae.

The portion of the material held at 75° F. for 14 days (Conditioned at 75°) showed much less resistance. The larvae from sugar pine had about the same resistance as that found in summer condition, while the larvae from lodgepole pine were in about the same condition as those tested in the early winter.

The portion of the lodgepole pine material conditioned at 75° F. and then exposed to 36° F. for 23 days (75° - 36°) re-developed resistance in the upper portion of the critical range but the ultimate point remained the same as that which was held at 75° F.

APPENDIX

WESTERN PINE BEETLE STUDIES

Test No. 45 of Laboratory Notes
March 5, 1936

Material and Procedure: Infested bark from the vicinity of Miami Ranger Station, Sierra National Forest, was collected March 3 and brought to Berkeley by truck the following day. Removed from the bark March 5 and exposed at once. This was a very healthy brood and was in an active condition.

Results:

Temperature °F	No. Larvae in Sample	Mortality %
Check	50	2
7½°	50	0
5°	100	3
2½°	50	22
0°	50	58
-2½°	50	66
-5°	50	100
-7½°	50	100

Test No. 48 of Laboratory Notes
March 18, 31 and April 1, 1936

Material and Procedure: Same material as No. 45. One lot of bark (a) held at 36° F. for 18 days, lot (b) held at 36° F. for 28 days and lot (c) held 18 days at 36° F. and 10 days at 20° F. Lots "b" and "c" exposed at 0° F. merely as "indicators".

Results:

36° for 18 days

Temperature °F	No. Larvae in Sample	Mortality %
Lot "a"		
Check	50	0
10°	50	0
7½°	50	0
5°	50	12
3°	50	18
0°	50	48
-2½°	50	48
-3°	50	85
-5°	50	96
Lot "b"		
0°	87	44
Lot "c"		
0°	100	56

36° for 28 days

36° 18 days + 20° 10 days

Test No. 49 of Laboratory Notes
March 24, 1936

Prolonged exposure at 7½°

Material and Procedure: Same material as used in No. 45. Held at 36° for 18 days. Removed from bark March 23 and exposures started the following day.

Results:

Temperature 7½° F.	
Length of Exposure	Mortality %
Check	2
1 hour	4
2 hours	2
4 hrs	6
8 hrs	8
16 hrs	6
24 hrs	10
2 days	6
3 days	12
4 days	16

MOUNTAIN PINE BEETLE STUDIES

Test No. 41 of Laboratory Notes
January 13, 1936

Material and Procedure: Material in sugar pine and ~~lodgepole~~ ponderosa pine resulted from a forced attack (August 12-20, 1935) of parent adults from lodgepole pine. Lodgepole brood was a natural infestation collected in Peregoy Meadows, Yosemite National Park - October 9, 1935. All material stored at Central Sierra field station. Brought to Berkeley by truck January 12. Larvae removed from bark January 13 and exposed at once.

Results:

	- HOSTS -								
	Sugar Pine			Ponderosa Pine			Lodgepole Pine		
Temperature	No. Larvae in Sample	Mortality %		No. Larvae in Sample	Mortality %		No. Larvae in Sample	Mortality %	
Check	25	0		25	0		25	4	
10°	25	8		-	-		-	-	
7½°	25	36		-	-		-	-	
5°	25	16		25	4		50	2	
2½°	25	20		25	4		25	0	
0°	25	12		25	4		25	8	
-2½°	25	56		25	4		50	10	
-5°	25	76		24	42		50	12	
-7½°	25	76		25	64		50	20	
-10°	23	96		25	96		50	66	
-12½°	25	100		25	100		50	100	

Test No. 42 of Laboratory Notes
January 29, 1936

Material and Procedure: Same material as No. 41 except held at 75° F. for 14 days and was in an active condition when exposed.

Results:

- HOSTS -

Temperature °F	Sugar Pine: No. Larvae in Sample	Sugar Pine: Mortality %	Lodgepole Pine: No. Larvae in Sample	Lodgepole Pine: Mortality %
Check	25	4	24	-
14°	25	12	-	-
12½°	25	88	25	4
10°	25	96	49	8
7½°	24	91	50	48
5°	25	100	50	46
2½°	25	100	50	68
0°	-	-	50	76
-2½°	-	-	50	92
-5°	-	-	24	100

Test No. 43 of Laboratory Notes
February 21, 1936

Material and Procedure: Same as Nos. 41 and 42 except that after developing at 75° F. for 14 days was placed at 36°F. for 23 days. Lodgepole brood only.

Results:

Temperature °F	No. Larvae in Sample	Mortality %
Check	24	4
0°	25	24
-2½°	50	64
-5°	50	98

Test No. 44 of Laboratory Notes
March 5, 1936

Material and Procedure: Natural infestation in lodgepole pine collected in Peregoy Meadows and Badger Pass, Yosemite National Park - October 9, 1935. Stored at Central Sierra field station until March 3, brought to Berkeley by truck March 4, removed from slabs March 5, and exposed at once.

Results:

(next page)

Results:

Temperature °F	No. Larvae in Sample	Mortality %
Check	20	5
5°	20	0
0°	20	10
-2½°	20	25
-5°	20	75
-7½°	20	75
-10°	20	95

Test No. 46 of Laboratory Notes
March 14, 1936

Material and Procedure: Material resulted from a forced attack on sugar pine, ponderosa pine and lodgepole pine by parent adults from sugar pine host. (July 18 to August 5). Stored at Central Sierra Field station and brought to Berkeley by truck March 13. Removed from bark and exposed March 14.

Results:

	- HOSTS -								
	Sugar Pine			Ponderosa Pine			Lodgepole Pine		
Temperature °F	No. Larvae in Sample	Mortality %		No. Larvae in Sample	Mortality %		No. Larvae in Sample	Mortality %	
Check	16	0		25	4		50	2	
12°	-	-		25	20		50	6	
10°	20	40		25	32		50	24	
7½°	20	50		25	20		50	28	
5° 5°	20	65		25	64		50	32	
3°	20	100		25	64		50	70	
0°	20	100		25	80		50	80	
-2½°	-	-		25	84		50	100	
-5°	-	-		25	100		50	100	

Test No. 47
March 16, 1936

Material and Procedure: Infested ponderosa pine collected in Modoc National Forest and brought to Berkeley by truck March 15. Removed from bark and exposed the following day.

Results:

Temperature °F	No. Larvae in Sample	Mortality %
Check	50	4
14°	50	8
12°	50	10
10°	50	10
7½°	100	59
5°	50	96
2½°	50	98
0°	50	100